Thin-layer scintillators of low-dimensional $Cs_3Cu_2I_5$ developed for charged-particle spectroscopy

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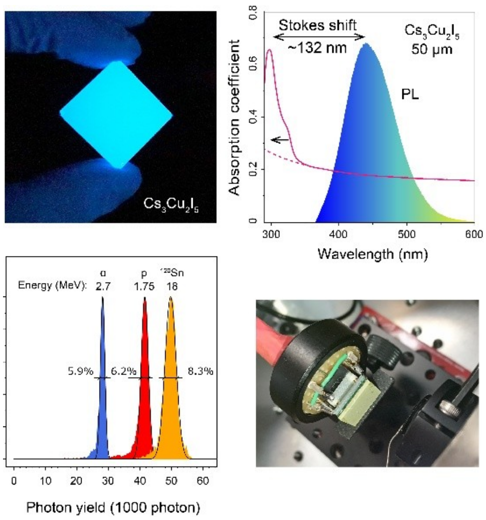

Low-dimensional perovskites constitute a rapidly expanding class of optically active materials, primarily developed for light-emitting and X-ray detection applications. A particular composition, $Cs_3Cu_2I_5$ has been shown to exhibit exceptional luminescence behavior arising from the natural formation of deep self-trapped excitonic states. Initial characterization revealed several beneficial properties, including a large Stokes shift, a broad blue emission spectrum, high defect tolerance, and good structural stability [1]. These findings motivated a more detailed investigation of its scintillation performance, especially given that its radioluminescence response to energetic ions and electrons has only been marginally explored, while responses to heavy ions have remained largely unaddressed due to the detrimental effect of luminescence quenching.

In this work, we investigated multiple observables of the scintillation response of $Cs_3Cu_2I_5$ to ion beams spanning a wide range of atomic masses and energies, as well as to electron irradiation. Key parameters of the spectroscopic performance, including absolute light yield, luminescence time structure, energy linearity, and energy resolution were systematically measured and benchmarked against commercial scintillators [1]. The $Cs_3Cu_2I_5$ samples were prepared as polycrystalline thin films with thicknesses of 30–60 µm, optimized to the stopping ranges of MeV-scale ions. For proton irradiation, the light yield and energy resolution were about 20000 photons/MeV and 5-7% (FWHM), respectively, while electron excitation yielded about 43500 photons/MeV [2]. Additional studies addressed radiation-damage tolerance and thermal-shock resistance, complemented by an investigation of the temperature dependence of scintillation properties over the range 4.2–473 K.

Our thin-layer deposition technology enables the fabrication of multilayer scintillation units that follow the operational concept of a phoswich detector. As a proof of concept, we constructed a test device consisting of $Cs_3Cu_2I_5$ thin layers deposited on either glass or scintillator substrates, coupled to SiPM detectors with digitized waveform readout. This detector architecture can be optimized for space applications that require miniaturized, low-power instrumentation, and it also offers robust operation in harsh environments for radiation-field exploration. One prototype has already been successfully tested aboard the ISS. Owing to the low-cost and scalable production of $Cs_3Cu_2I_5$ thin-layers an additional application area is anticipated as high-throughput monitoring of radioactive surface contamination, supporting public safety in both accidental and intentional pollution scenarios.

1. M. Hunyadi, et al.: "Scintillator of polycrystalline perovskites for high-sensitivity detection of charged-particle radiations", *Adv. Funct. Mater.*, **32**, 2206645 (2022).
2. M. Hunyadi, et al.: "Scintillation response of 0-dimensional $Cs_3Cu_2I_5$ thin layers to light and heavy ion irradiation", *Adv. Photonics Res.* **6**, 2400217 (2025).